PONDICHERRY UNIVERSITY

DEPARTMENT OF STATISTICS

SYLLABUS FOR M.Sc. STATISTICS
(CBCS Pattern)
Effective from the Academic Year 2016-2017
Aim of the Course
The Degree of Master of Science in Statistics aims to train the students in the development and applications of Statistical techniques for analyzing data arising in the scientific investigation of problems in the various disciplines. It is also proposed to provide first hand practical experience in handling modern statistical softwares in the analysis of such data.

Eligibility for admission
Candidates for admission to the first year of the M.Sc. (Statistics) degree programme shall be required to have passed the B.Sc. degree examination of any Indian University recognized by the University Grants Commission with Statistics as the main subject or Mathematics as the main subject with Mathematical Statistics as one of the minor subject and a minimum of 55% marks in the main and allied subjects.

Duration of the Course
The course shall be of two years duration spread over four semesters. The maximum duration to complete the course shall not be more than 8 semesters.

Eligibility for admission to Examination
A candidate shall be permitted to appear for the M.Sc. examination in a subject of study only if he/she secures not less than 70% attendance in the subject concerned.

Medium: The medium of instruction shall be English.
Passing Minimum and Weight age of marks
The weight age of marks for Continuous Internal Assessment (CIA) and end semester examinations shall be 40 and 60 respectively. As per the Choice Based Credit System regulations of the Pondicherry University, a student is declared as pass in a given subject he / she secures

(a) A minimum of 40% marks in end-semester exam and
(b) A minimum of 50% marks in aggregate when Internal assessment and End-Semester marks are added

Supplementary Exam
(a) A failed student who meets the attendance requirement (70%) and has a minimum of 40% in the Internal Assessment marks may be permitted to register for the next End Semester examination in the following semester itself
(b) Students who have failed due to insufficient attendance and / or less than 40% in the Internal Assessment marks should repeat the course as and when it is offered.

Continuous Internal Assessment
The weight age of 40 marks for Continuous Internal Assessment component shall consist of the following:

a) Internal Assessment Tests (two) (2 x 15) = 30 marks
b) Seminars/Assignments/Presentations/Viva etc. (1 x 10) = 10 marks

Internal Total = 40 marks
M.Sc. (STATISTICS) – COURSE STRUCTURE  
(With effect from 2016-17 onwards)

Objectives
The present course is intended to provide a platform for talented students to undergo higher studies in the subject as well as to train them to suit the needs of the society. Apart from teaching core Statistics subjects, the students are also trained to handle real life problems through practical classes. As part of the course, the students are taught some programming languages and also trained in various statistical softwares such as SPSS, SYSTAT, R language, MINITAB.

Eligibility
B.Sc. degree in Statistics or Mathematics with Mathematical Statistics as a minor subject with a minimum 55% of marks.

Duration of the Course
The course shall be of two years duration spread over four semesters. The maximum duration to complete the course shall not be more than 8 semesters.

Medium
The medium of instruction shall be English.

Choice Based Credit System (CBCS)
The M.Sc. Statistics program is offered through a unique CBCS. The salient feature of the CBCS is that the program is offered through credit based courses. Subjects are divided into Hard Core and Soft Core. Hard Core subjects are compulsory. The students have the choice to select from among the list of soft core subjects. Soft core subjects are similar to elective subjects.

A student is expected to complete a minimum of 72 credits within four semesters. Students are assessed and awarded letter grades based on their performances in the respective courses.
## PONDICHERRY UNIVERSITY
### CHOICE BASED CREDIT SYSTEM
### M.Sc. STATISTICS SYLLABUS

Effective from the Academic Year 2016 – 2017

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSE CODE</th>
<th>TITLE OF THE COURSE</th>
<th>NATURE OF THE COURSE</th>
<th>NO. OF CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>STAT 411</td>
<td>Linear Algebra and Matrix Theory</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 412</td>
<td>Probability Theory</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 413</td>
<td>Distribution Theory</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 414</td>
<td>Programming in R (Lab. Based)</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>STAT 421</td>
<td>Theory of Estimation</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 422</td>
<td>Sampling Theory</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 423</td>
<td>Stochastic Processes</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 424</td>
<td>Statistical Laboratory - I with (Based on STAT 421 and STAT 422)</td>
<td>Hard Core</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>3</td>
</tr>
<tr>
<td>III</td>
<td>STAT 531</td>
<td>Multivariate Statistical Analysis</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 532</td>
<td>Testing of Statistical Hypotheses</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 533</td>
<td>Linear Models and Regression Analysis</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 534</td>
<td>Statistical Laboratory - II with (Based on STAT 531, STAT 532 STAT 532)</td>
<td>Hard Core</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>STAT 541</td>
<td>Design and Analysis of Experiments</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STAT 542</td>
<td>Statistical Laboratory - III with (Based on STAT 541)</td>
<td>Hard Core</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>STAT 543</td>
<td>Project and Viva-Voce/Dissertation</td>
<td>Hard Core</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>Soft Core</td>
<td>3</td>
</tr>
</tbody>
</table>

### Soft Core Papers

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Semester II</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 415</td>
<td>STAT 425</td>
</tr>
<tr>
<td>STAT 416</td>
<td>STAT 426</td>
</tr>
<tr>
<td>STAT 417</td>
<td>STAT 427</td>
</tr>
<tr>
<td></td>
<td>STAT 428</td>
</tr>
<tr>
<td>Semester III</td>
<td>Semester IV</td>
</tr>
<tr>
<td>STAT 535</td>
<td>STAT 544</td>
</tr>
</tbody>
</table>

3
STAT411 - LINEAR ALGEBRA AND MATRIX THEORY

CREDITS: 4

Unit I
Vector Spaces, Sub-spaces, Basis of a vector space – Vector spaces with inner products - Gram-Schmidt orthogonalization.

Unit II
Linear transformation (LT) – Properties – Matrix of a linear transformation – Matrix of composite transformation – Matrix of an inverse transformation – Change of basis - Orthogonal transformation - Dual space.

Unit III
Linear equations – Solution space and null space – Sylvester’s law of nullity – Generalized inverse of a matrix – Moore – Penrose inverse

Unit IV
Eigen values and Eigen vectors of an LT – left Eigen vectors, right Eigen vectors, Diagonalizable LT – Lambda matrix, Composition of lambda matrices, Operator polynomial, Cayley-Hamilton theorem and minimal polynomial for an LT – Eigen values of matrix polynomials.

Unit V

Text Books

Reference Books
Unit I

Unit II

Unit III
Convergence of a sequence of random variables - convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean - Weak and Complete convergence of distribution functions – Helly-Bray theorem.

Unit IV

Unit V

Text Books

Reference Books
STAT 413 – DISTRIBUTION THEORY

CREDITS: 4

Unit I
Brief review of distribution theory, distribution of functions of random variables - Laplace, Cauchy, Inverse Gaussian, Lognormal, Logarithmic series and Power series distributions - Multinomial distribution

Unit II
Bivariate Binomial – Bivariate Poisson – Bivariate Normal- Bivariate Exponential of Marshall and Olkin - Compound, truncated and mixture of distributions, Concept of convolution

Unit III
Multivariate normal distribution (Definition and Concept only) - Sampling distributions: Non-central chi-square, t and F distributions and their properties - Distributions of quadratic forms under normality-independence of quadratic form and a linear form- Cochran’s theorem

Unit IV
Order statistics, their distributions and properties- Joint and marginal distributions of order statistics - Distribution of range and mid range - Extreme values and their asymptotic distributions (concepts only)

Unit V

Text Books

Reference Books
Unit I
R language Essentials: Expressions and objects, Assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection; examples.

Unit II
R Programming: conditional statements – if and if else; loops – for, while, do-while; functions – built-in and user defined; Data entry – reading from text file, data editor; examples.

Unit III
Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises.

Unit IV
Probability and Distributions: Random sampling and combinatorial; obtaining density, cumulative density and quantile values for discrete and continuous distributions; generating samples from discrete and continuous distributions; Plotting density and cumulative density curves; Q-Q plot.

Unit V
Correlation: Pearson, Spearman and Kendall’s correlation; Regression – fitting, obtaining residuals and fitted values; one and two sample tests for mean and variance – one way and two way ANOVA.

Text Books
1. Michael J.Crawley (2007), The R Book, John Wiley and Sons Ltd.

Lab Exercises:
1. Operations on vectors and matrices
2. Creating and manipulating data frames.
3. Writing user defined functions for finding arithmetic mean, median, factorial, matrix addition and multiplication.
4. Bar and Pie charts.
5. Box plots for single and multiple groups.
6. Density and cumulative density plots for Binomial, Poisson, Normal and exponential distributions.
7. Checking Normality using Histogram and Q-Q plot.
8. Correlation coefficient – Pearson’s, Spearman and Kendall’s Tau.
10. One sample and two sample t test.
11. One way and two way ANOVA.
Unit I

Unit II
The information measure – Cramer – Rao (CR) inequality – Chapman – Robbins (KCR) inequality (single parameter case only) – Bhattacharya inequality (single parameter case only) – minimum variance bound estimator- Invariant (equivariant) estimators (concepts only)

Unit III
Uniformly minimum variance unbiased estimators (UMVUE)- condition for the existence of UMVUE- Completeness and Bounded completeness- Relation between complete statistic and minimal sufficient statistic- Rao – Blackwell Theorem- Lehmann – Scheffé’s theorem.

Unit IV

Unit V

Text Books

Reference Books
5. Srivastava, Khan and Srivastava (2014), Statistical Inference: Theory of Estimation, PHI, India
Unit I

Unit II

Unit III

Unit IV
Cluster Sampling: Equal cluster sampling – Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance, varying probability cluster sampling – Two stage sampling – variance of the estimated mean – Double Sampling for stratification and Ratio estimation

Unit V

Text Books

Reference Books

STAT 423 – STOCHASTIC PROCESSES CREDITS: 4

Unit I

Unit II
Markov chains continuous in time – General pure birth processes and Poisson process, birth and death processes, finite state continuous time Markov chains.

Unit III
Branching processes discrete in time – Generating functions relations – Mean and variance – Extinction probabilities – Concept of Age dependent Branching process

Unit IV
Renewal processes – Definition and examples – key renewal theorem – Study of residual life time process

Unit V
Stationary process – weakly and strongly stationary process – Moving average and Autoregressive processes and their covariance functions – Brownian Motion process – Joint probabilities for Brownian motion process – Brownian motion as a limit of random walk

Text Books

Reference Books
I. Estimation (20 marks)

1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean, difference of means, variance and ratio of variances.

II. Sampling Theory (20 marks)

2. PPSWR – Hurwitz Thompson estimator - Des Raj ordered estimator – Murthy’s unordered estimator – Midzuno scheme.
3. Linear and circular systematic sampling.
4. Stratified sampling – SRS, PPSWR, PPSWOR
5. Cluster sampling – of equal sizes.
6. Ratio, Regression and Difference estimation.

III. Computations based on SPSS software (20 marks)

1. Graphical plots: Box-Whisker plots, Histograms and Population Pyramids
2. Random number generation (i) Binomial, (ii) Poisson, (iii) Normal
4. Computation of simple regression and test for intercept and slope.
5. Fitting of curves – parabola, cubic and exponential.
6. Testing of Hypothesis
   (i) Two sample t-test and confidence interval
   (ii) Paired Samples t-test and confidence interval
   (iii) Chi square for independence of attributes
7. One way ANOVA with post hoc tests (Dunnett’s test and Duncan’s Multiple Range Test (DMRT)).
8. Two Way ANOVA with post hoc tests (Tukey’s and Bonferonni’e test)).
Unit I
Multivariate normal distribution – Marginal and conditional distributions – characteristic function. Maximum likelihood estimation of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known.

Unit II
Total, Partial, Multiple correlation in the Multivariate setup – MLEs of Total, Partial and Multiple correlation coefficients. Sampling distributions of Total and Multiple Correlation in the null case. Hotelling $T^2$ statistic, derivation and its distribution – Uses of $T^2$ statistic – Relation between $T^2$ and $D^2$ – Mahalanobis $D^2$ statistic and its distribution.

Unit III

Unit IV
Classification problems – Classification into one of two populations (known and unknown dispersion matrix) – Classification into one of several populations – Fisher’s Linear discriminant function.

Unit V

Text Books

Reference Books
STAT 532 – TESTING OF STATISTICAL HYPOTHESES 

CREDITS: 4

Unit I
Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, Most powerful tests, Uniformly most powerful test, Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma and its applications

Unit II
Unbiasedness for hypothesis testing, Uniformly most powerful unbiased tests, Unbiased tests for one parameter exponential family, Similar test and complete sufficient statistics, Similar tests with Neyman structure, Locally most powerful tests.

Unit III
Invariant tests, maximal invariants, Uniformly most powerful invariant tests, Consistent tests, Likelihood ratio test, its properties and its asymptotic distribution, Applications of the LR method.

Unit IV
Non-parametric tests: Goodness of fit test : Chi-square and Kolmogorov Smirnov test - Test for randomness, Wilcoxon Signed rank test – Two sample problem: Kolmogrov-Smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test

Unit V
Sequential tests: Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications – Determination of the boundary constants – Operating Characteristic and expected sample size of SPRT – Optimum properties of SPRT.

Text Books

Reference Books
Unit I
Full rank linear model – least square estimators of the parameters and their properties – Gauss-Markov theorem – Model in centered form – Estimators under normality assumption and their properties – Coefficient of determination – Generalized least squares – misspecification of the error structure and the model.

Unit II
Test for overall regression and for a subset of the parameters – test in terms of $R^2$ – General Linear Hypothesis testing – special cases – confidence region for the parameters and the mean – prediction intervals – likelihood ratio tests for the parameters – study of the residual outliers and influential observations

Unit III
Selection of input variables and model selection – Methods of obtaining the best fit – Stepwise regression, Forward selection and backward elimination – Multicollinearity – Collinearity diagnostics – Causes, Consequences and Remedy – Departure from normality

Unit IV
Introduction to general non-linear regression – Least squares in non-linear case – Estimating the parameters of a non-linear system – Reparametrisation of the model – Non-linear growth models – Concept of non-parametric regression

Unit V
Robust regression – Linear absolute deviation regression – M estimators – Robust regression with rank residuals – Resampling procedures for regression models – methods and its properties (without proof) - Jackknife techniques and least squares approach based on M-estimators.

Text Books

Reference Books
I Testing of Hypotheses (30 marks)

1. Construction of randomized and nonrandomized MP, UMP and UMPU tests of hypotheses and drawing the power curves.
2. Construction of SPRT and its OC and ASN curves.
3. Non parametric tests:
   Kolmogorov Smirnov test, Mann-Whitney U test, Median test for k-sample problem, Kruskal Wallis test and Friedman’s test

COMPUTATIONS BASED ON SPSS (30 MARKS)

II Multivariate Statistical Analysis

1. Test for equality of mean vectors when covariance matrix is unknown (Hotelling’s T^2 test)
2. Test for Two Covariance matrices
3. Discriminant Analysis
4. Canonical correlation and canonical variables
5. One Way MANOVA with Post hoc tests (DMRT and Tukey’s).
6. Principal Component Analysis
7. Factor Analysis

III Linear Models and Regression Analysis

1. Fitting of Multiple linear regression model
2. Residual Analysis for model adequacy, detection of outliers and influential observations
3. Variable Selection procedures
4. Collinearity Diagnostics
Unit I
Notion of design matrix- general analysis of design models (Inter and Intra Block analysis) – C Matrix and its properties – Expected Mean Squares (EMS) and its uses- Algorithm for calculating EMS – Two way elimination of heterogeneity – Orthogonality – Connectedness and resolvability

Unit II
Principles of scientific experimentation – Basic Design: Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) – Analysis of RBD (with one observation per cell, more than one but equal number of observations per cell) – Derivation of one and two missing values: Iterative and non-iterative methods – Loss of Efficiency due to missing values- Multiple comparison test: Least Significant Difference, Student Newman Kuel, Duncan’s Multiple Range, Tukey tests.

Unit III
Factorial experiments: $2^n$ and $3^n$ experiments and their analysis – Complete and Partial Confounding - Fractional Replication in Factorial Experiments – Split plot and strip plot design and their analysis.

Unit IV
Balanced Incomplete Block Design (BIBD)– Types of BIBD – Simple construction methods – Concept of connectedness and balancing – Intra Block analysis of BIBD – Recovery of InterBlock information – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only.

Unit V
Youden square and lattice design and their analysis – Analysis of Covariance with one concomitant variable in CRD and RBD only

Text Books
2. Douglas C. Montgomery (2009) : Design and Analysis of Experiments, 7/e, John Wiley and Sons, (Chapter 16 for Parts of Unit IV and Unit V)

Reference Books
I. Design of Experiments (60 marks)

1. Multiple Comparison tests (Least Significant Difference (LSD) test, Bonferonni’s test)
2. Missing Data Analysis – one and two observations in RBD
3. Missing Data Analysis – one and two observations in LSD
4. $2^4, 3^2$ factorial experiments
5. Fractional factorial experiments
6. Complete confounding in $2^4, 3^2$ factorial experiments
7. Partial confounding in $2^4, 3^2$ factorial experiments
8. Split plot design
9. BIBD
10. Youden Square Design
11. Analysis of Covariance – CRD – One Concomitant Variable
12. Analysis of Covariance – RBD – One Concomitant Variable
1. A project work is compulsory and shall be offered in semester IV. Project submission is in Semester IV but the allocation of students should be done at the end of II semester.

2. A project work may be taken individually or by a group of students (not more than three).

3. Project work shall be supervised by a co-ordinating group faculty members assigned by the Head of the Department at the end second semester.

4. Review meeting are to be done periodically

5. The project work should be selected in such a way that there is enough scope to apply and demonstrate the statistical techniques learnt in the course.

6. At the end of the semester, a report on the work done should be submitted (two copies). If a team of two students jointly do a project work then they must submit individual reports separately (not copy of the same report).

7. The project report shall clearly state the selected problem, the statistical methodologies employed for data collection and analysis and the conclusions arrived at. Details of previous studies in the area and related references should also be given.

8. The project work will be assessed for a maximum of 100 marks. Each student will give a seminar before the end of the semester on their project work which will be evaluated internally for a maximum of 40 marks. There will be an external viva-voce examination for a maximum of 20 marks by an internal and an external examiner. The parameters for viva voce include (i) Clarity of presentation (ii) Clarity of the content / concept (iii) response to the queries and (iv) relevance of topic for carrying out the project. The project report will be valued by the same external and internal examiner for a maximum of 40 marks.
UNIT I
(Review of Linear Programming Problem (LPP) – Simplex, Big-M and Two Phase methods)
– Revised simplex method – Duality in LPP – Dual Simplex method – Some important
theorems on duality – Sensitivity Analysis – Variation in cost vector and requirement vector –
Addition and deletion of single variable and single constraint

UNIT II
Integer Programming Problem (IPP) – Gomory’s cutting plane algorithm – Mixed IPP –
Branch and Bound technique – Dynamic programming problem (DPP) – Bellman’s principle
of optimality – General formulation – Computation methods and application of
DPP – Solving LPP through DPP approach

UNIT III
Inventory models – Deterministic inventory models – Classic EOQ model – EOQ with
price breaks – EOQ with storage limitations – Probabilistic Inventory models – Continuous
review model – Single period model – No setup model – setup model (s-S policy)

UNIT IV
Non-linear programming problem – Kuhn-Tucker conditions – Quadratic Programming
Problem (QPP) – Wolfe’s and Beale’s algorithms for solving QPP – Convex programming

UNIT V
Queueing theory – Basic characteristics of queueing models – Arrival and service
distribution – steady state solution of M/M/1 and M/M/C models with associated distribution of queue
length and waiting time – M/G/1 queue – steady results using embedded Markov chain
Methods – Pollaczek Khinchin formula.

TEXT BOOKS
   McGraw Hill
   and Sons, New Delhi.
   Queuing Theory, John Wiley & Sons

REFERENCE BOOKS
Unit I
Modified control charts for mean – CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotellings $T^2$ control charts and Economic design of X-bar chart

Unit II
Process Capability analysis: Meaning, Estimation technique for capability of a process – Capability Indices: Process capability ratios $C_p$, $C_{pk}$, $C_{pm}$, $C_{mk}$, $C_{pc}$ – Process capability analysis using a control chart – Process capability analysis using design of experiments

Unit III
Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves – MILSTD -105E Tables

Unit IV
Acceptance sampling variables for process parameter – Sequential plans for process parameter ($\sigma$ known and unknown) – Sampling variables for proportion non-conforming - $\bar{X}$ method, K method –

Unit V
Double specification limits – M-method, Double sampling by variables - MILSTD -414 Tables – Continuous Sampling plan – CSP-1, CSP-2, CSP-3, Wald and Wolfowitz SP-A and SP- B

Text Books

Reference Books
Unit I

Unit II
Life tables: Construction of a life table, Graphs of l_x, q_x, d_x, Funtions L_x, T_x, and E_x. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity.

Unit III
Fertility: Measures of Fertility, Reproductively formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable Populations, Calculation of the age distribution of a stable population, Model Stable Populations.

Unit IV

Unit V
Ageing of the population, Estimation of demographic measures from incomplete data.

Text Books:

Reference Books:
SEMESTER – II

STAT 425–DECISION THEORY CREDITS: 3

Unit I
Basic elements of a decision problem - Randomized and non-randomized decision rules - Estimation and testing of hypothesis as decision problems - Bayes approach to inference and decision -

Unit II
Loss functions - Prior and Posterior distributions and its analysis for Bernoulli, Poisson, and normal processes - Decision principles and Baye’s risk–

Unit III
Utility theory - axioms, construction of utility functions, sufficiency, equivalence of classical and Bayesian sufficiency, complete and essentially complete classes of decision rules

Unit IV
Minimax analysis - Basic elements of game theory - General techniques of solving games - Finite games - Supporting and separating hyperplane theorems - Minimax theorem - Minimax estimation for normal and Poisson means

UNIT V
Admissibility of Bayes and minimax rules, General theorems on admissibility, Robustness of Bayes rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.

Text Books:

Reference Books:
1. Zellener (1971): An Introduction to Bayesian Inference in Econometrics, Willey
STAT 426 - TOTAL QUALITY MANAGEMENT

UNIT I
Need for TQM, evolution of quality, Definition of quality, TQM philosophy – Contributions of Deming, Juran, Crosby, Taguchi and Ishikawa.

UNIT II
Vision, Mission, Quality policy and objective, Planning and Organization for quality, Quality policy Deployment, Quality function deployment, Analysis of Quality Costs.

UNIT III

UNIT IV
PDSA, The Seven QC Tools of Quality, New Seven management tools, Concept of six sigma, FMEA, Benchmarking, JIT, POKA YOKE, 5S, KAIZEN, Quality circles.

UNIT V

TEXT BOOKS

REFERENCE BOOKS
Unit I
Nature and Scope of Econometrics - Review of General Linear Model (GLM), Ordinary Least Squares (OLS), Generalized Least Squares (GLS) and Multicollinearity

Unit II
Heteroscedasticity - Autocorrelation, its consequences and tests - Ridge regression - Linear regression with stochastic regressors - Instrumental variable estimation - Errors in variables - Autoregressive linear regression - Distributed lag models.

Unit III
Simultaneous linear equations model - Identification problem - Restrictions on structural parameters - rank and order conditions - Restrictions on variances and covariances - Estimation in simultaneous equations model

Unit IV
Forecasting - Univariate forecasting methods - Forecasting in regression models - Forecasting with Simultaneous equations model - Evaluation of forecasts - Combination of forecasts

Unit V
Definition of causality - Granger causality - testing of causality - Cointegration, Bivariate cointegration tests - multivariate cointegration.

Text Books:

Reference Books:
Unit I
Basic deterministic model: Cash flows, discount function, interest and discount rates, balances and reserves, internal rate of return, The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.

Unit II
Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern reserves, recursion, detailed analysis of an insurance, bases for reserves, non forfeituary values, policies involving a return of the reserve, premium difference and paid-up formula.

Unit III
Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves. The general insurance – annuity identity, Select morality: Select an ultimate tables, Changed in formulas.

Unit IV
Multiple life contracts: Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances

Unit V
Multiple decrement theory: Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

Text Books

Reference Books
SEMESTER III

STAT 535 – RELIABILITY THEORY  CREDITS: 3

Unit I
Introduction to Reliability and its needs; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Modules of coherent systems; Reliability of a coherent systems; Reliability importance of components; Bounds on System Reliability.

Unit II
Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; loss of memory property of Exponential distribution - parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.

Unit III
Notions of Ageing; Classes of life distributions and their duals - preservation of life distribution classes for reliability operation - Formation of coherent systems, convolutions and mixtures.

Unit IV
Univariate stock models and life distributions arising out of them: cumulative damage model, shock models leading to univariate IFR, Successive shock model; bivariate shock models; common bivariate exponential distributions due to shock and their properties. Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process.

Unit V
Stress-Strength reliability - Concepts and its estimation for exponential, weibull and gamma distributions; Reliability growth models; probability plotting techniques; Hollander – Proschan and Deshpande tests for exponentiality – Basic ideas of accelerated life testing.

Text Books:

Reference Books:
STAT 536 - TIME SERIES ANALYSIS  

CREDITS: 3

Unit I
Exploratory Time Series Analysis: Forecasting trend and seasonality based on smoothing. Methods of Exponential and moving average smoothing; Types and implications of interventions; Outliers, additive and innovational outliers, procedure for detecting outliers

Unit II
Stationary Stochastic models: weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, Conditions for stationarity and invertibility,

Unit III
Models for Time Series: Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods

Unit IV
Spectral analysis and decomposition: Spectral analysis of weakly stationary process, Periodogram and correlogram analysis, Spectral decomposition of weakly AR process and representation as a one-sided MA process – necessary and sufficient conditions, implication in prediction problems.

Unit V
Modeling Seasonal Time Series: seasonal ARIMA models, estimation and forecasting, Fitting ARIMA models with Box-Jenkins procedure, Identification, Estimation, Verification, Test for white noise, Forecasting with ARMA models.

Text Books:

Reference Books:
STAT 537 - ELEMENTS OF QUEUEING THEORY

Unit I

Unit II
Poisson Queuing Models with single server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/1): (∞/FIFO) and (M/M/1): (N/FIFO) Models, simple numerical problems

Unit III
Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/C): (∞/FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, simple numerical problems

Unit IV
Non Poison Queuing Models (Erlangian): Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/Ek/1), (Ek/M/1), simple numerical problems

Unit V
General Queuing Models: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/G/1), (G/M/1), Simple numerical problems

Text Books

Reference Books
4. J.Medhi (2009), Stochastic Processes, 3/e, New Age International
Unit I
Introduction, need of simulation, physical versus digital simulation, Buffersies needle problem, Use of simulation in defence, inventory problems and other fields.

Unit II
Random number generation: Congruential generators, Metropolis Hasting algorithm, Statistical tests for pseudo random numbers. Random number generation from mixture of distributions, compound distributions.

Unit III

Unit IV
Monte Carlo integration and variance reduction techniques. Hit or Miss Monte Carlo Method, Sample mean Monte Carlo method.

Unit V

Text Books

Reference Books
STAT 544 - SURVIVAL ANALYSIS

CREDITS: 3

Unit I
Concepts of time, Orderand random Censoring, likelihood in these cases. Life distributions- Exponential, Gamma, Weibull , Lognormal , Pareto , Linear Failure rate. Parametric inference (Point estimation, scores, MLE)

Unit II
Life tables, failure rate, mean residual life and their elementary properties. Concept of Ageing, Types of Ageing classes and their properties and relationship between them , Bathtub Failure rate, Concept of Inverse Hazard rate.

Unit III
Estimation of survival function Acturial Estimator, Kaplan- Meier Estimator, Estimation under the assumption of IFR / DFR . Tests of exponentiality against non- parametric classes- Total time on test, Deshpande test.

Unit IV
Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi- parametric regression for failure rate, Cox’s proportional hazards(PH) model with one and several convariates and estimation problems in Cox’s PH Model. Rank test for the regression coefficients.

Unit V
Introduction to Competing risks analysis and estimation problems in competing risk model for parametric and non- parametric semi parametric set up. Ideas of Multiple decrement life table and its applications.

Books for Study:

Books for Reference:
Unit I
Statistical Methods in Clinical Trials: Introduction to clinical trial and it’s phases I, II, III and IV, statistical designs-fixed sample trials: simple randomized design, stratified randomized crossover design; Sequential design - open and close sequential design. Randomization-Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple.

Unit II

Unit III

Unit IV
ROC Curve analysis - Estimation of Binormal Model and the Area under the Curve, its applications – Properties of ROC curve - Kullback –Leibler Divergence (KLD) – definition – functional relationship between Kullback –Leibler Divergence and the slope of the ROC curve – derivations of KLD expressions for Bi-normal ROC model

Unit V
Repeated Measures ANOVA – One Way and Two Classified Data –Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias – information bias and selection bias

Text Books

Reference Books
Unit I

Unit II

Unit III
Nearest Neighbor classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression

Unit IV

Unit V
Case studies based on k means clustering - fuzzy c means clustering - kNN classification - Binary logistic regression using R programming language.

Text Books
1. Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education. (relevant portions of Chapters 1, 2, 4, 5 and 8).

Reference Books
Unit I
Introduction about Thomas Bayes - Motivations and Contributions - Evaluation of Subjective probability of an event using a subjectively unbiased coin - Subjective prior distribution of a parameter – Bayes theorem and computation of the posterior distribution.

Unit II
Introduction of Prior Distributions, Types of Prior Distributions, Proper Prior - Enlarging the natural conjugate family by enlarging hyper parameter space - mixtures from conjugate family - choosing an appropriate member of conjugate prior family - Non informative, improper and invariant priors - Jeffrey’s invariant prior

Unit III
Bayesian point estimation: Prediction problem from posterior distribution - Bayes estimators for absolute error loss, squared error loss, linex loss function, Jeffrey’s and 0 -1 loss - Generalization to convex loss functions - Evaluation of the estimate in terms of the posterior risk

Unit IV
Bayesian interval estimation: Credible intervals - Highest posterior density regions - Interpretation of the confidence coefficient of an interval.

Unit V
Bayesian Testing of Hypothesis: Prior and Posterior odds - Bayes factor for various types of testing hypothesis problems - Monte-Carlo Integration and Basic Concepts on Markov chain Monte Carlo techniques (MCMC)(without proof).

Text Books

Reference Books
SOFT CORE COURSE FOR OTHER DEPARTMENTS

STAT 418 - STATISTICAL METHODS

Credits: 3

Unit I

Unit II
Measures of central tendency – Mean, Median and Mode – Measures of dispersion – Range, Quartile deviation and Standard deviation – Coefficient of variation and skewness

Unit III

Unit IV
Elementary Probability theory:Addition theorem – Conditional probability and Multiplication theorem - Bayes’ Theorem – Random variables and probability distributions – Binomial, Poisson , Normal (simple applications of the distribution) – Sampling distributions: t, F and chi-square (definition only)

Unit V
Hypothesis testing:Basic concepts in Hypothesis Testing – Types of error – Tests for Mean and Proportion based on Normal and Student t-distribution - Chi-square test for independence of attributes – One-way and two-way Analysis of Variance

Text Books

Reference Books